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The effect of using technology and self-monitoring to teach basic facts to children at risk

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THE EFFECT OF USING TECHNOLOGY AND SELF-MONITORING TO TEACH BASIC FACTS TO CHILDREN AT RISK

by

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Dedication

I would like to dedicate this research in memory of my uncle, Sebastiano DiBlasi, Ph.D. Affectionately known as Ben, he was a lifelong learner and inspired me to pursue an advanced degree.

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Abstract

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TO CHILDREN AT RISK
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The purpose of this study was to investigate whether or not the use of technology would increase automaticity of basic subtraction facts with “at risk” students and whether or not self-monitoring would motivate “at risk” students to improve their math scores to achieve automaticity of basic subtraction facts. Participants included four “at-risk” second graders from an elementary school in a small suburban community in southern New Jersey. The study took place over 11 weeks and was conducted by the classroom teacher. The first week consisted of collecting baseline data followed by five weeks of students using the *Everyday Mathematics* online Facts Workshop Game and five weeks of students self-monitoring their progress. A multiple baseline single subject design with A B C phases was used. All four students had an increase in automaticity of basic subtraction facts. Findings indicate that both interventions are effective in improving math scores to achieve automaticity of basic math facts.

Table of Contents

Abstract	v
List of Tables	ix
List of Figures	x
Chapter 1: Introduction	1-6
Statement of Problems	1
Significance of the Study	5
Research Questions	5
Chapter 2: Literature Review	7-28
Students at Risk in Learning Basic Math Facts	8
Teaching Basic Math Facts to Achieve Automaticity	10
Cover-Copy-Compare (CCC)	10
Detect, Practice, and Repair (DPR)	17
Explicit Instruction	19
Timed Practice	20
Using Technology in Teaching Basic Math Facts	23
Self-management to Promote Automaticity in Learning Basic Math Facts	25
Summary	27
Chapter 3: Methods	29-36
Setting	29
School and Community	29
Classroom	29

Table of Contents Continued

Participants	30
Students	30
Teachers	31
Materials	32
Instructional Materials	32
Measurement Materials	32
Software Package	33
Self-monitoring	33
Research Design	33
Procedures	34
Measurement Procedures	34
Instructional Procedures	34
Data Analysis	35
Chapter 4: Results	37-39
Chapter 5: Discussion	40-43
Findings	40
Limitations	41
Implications	42
Conclusions and Recommendations	42
References	44-46
Appendix A: Assessment A	47

Table of Contents Continued

Appendix B: Assessment B	48
Appendix C: Assessment C	49
Appendix D: Assessment D	50
Appendix E: Assessment E	51
Appendix F: Self-monitoring graph	52
Appendix G: Instructional Procedures (Phase B)	53
Appendix H: Instructional Procedures (Phase C)	54

List of Tables

Table Page

Table 1 General Information of Participating Students 31

List of Figures

Figure	Page
Figure 1 Student 1 and student 2's math performance	37
Figure 2 Student 3 and student 4's math performance	38

Chapter 1

Introduction

Statement of Problems

Having been an elementary school teacher for the past eight years, I have had an opportunity to teach many children mathematics. These children have ranged in age from kindergarten to sixth grade and have had varying degrees of cognitive functioning. Through my experiences, it has become very clear that mastering basic math facts is critical to the mathematical success of elementary students. The mastery of basic facts is so important and often predicts mathematic success because it is the foundation for advanced concepts and skills. Unfortunately, some students have a very difficult time committing basic math facts to memory.

Automaticity, achieved through repeated practice, requires a learner's accurate and quick responding to basic math facts (Poncy, Duhon, Lee, & Key, 2010). If a student needs a wait time to figure out the answer, he/she has not yet reached automaticity, even if the answer is correct. According to Woodward (2006), automaticity in math facts is fundamental to success in many higher levels of mathematics. Lack of automaticity with basic facts makes it difficult for children to progress to more advanced concepts. Thus, they are less likely to engage in mathematics, which may cause them to fall further behind in developing math skills (Poncy, Skinner, & Axtell, 2010). Without the ability to retrieve facts directly or automatically, students are likely to experience a high cognitive load as they perform a range of complex tasks. Once the students progress to secondary-school mathematics, tasks such as finding common multiples when adding fractions with unlike denominators and factoring algebraic equations will become challenging (Woodward, 2006).

In my classes, I have seen the importance of children reaching automaticity with basic math facts. Therefore, I decided to make it a personal mission to facilitate student learning using the most effective strategy or combination of strategies. The math program used to teach my second grade general education students, as mandated by the school district in which I work, is *Everyday Mathematics: The Common Core State Standards Edition*. While I think it serves most students quite well, there are not sufficient drills and practices for students exhibiting difficulty in learning basic math facts. Therefore, I currently supplement the curriculum by implementing timed addition and subtraction fact drills with all of my students. These drills consist of sixty problems with “like” addends and subtrahends. For example, one drill may focus on adding zeros and ones while another drill may focus on “doubles” facts.

I have found that most children do very well on the timed fact tests and truly remember the basic facts. However, it is evident that the supplemental strategies I am implementing are not proving effective for the “at-risk” students. Even after a week or two of practicing “like” facts using the same exact practice sheets, they often do poorly on the test and have difficulty achieving automaticity. Having said this, many questions come to my mind. Perhaps teaching math facts with similar addends is not a wise choice? Maybe the fact tests should consist of mixed review? Perhaps there is not enough motivation for the children to do well on these fact tests? Maybe they need some sort of positive reinforcement? Perhaps the paper and pencil method of practicing these facts is not appropriate for them? Maybe the number of problems I assigned is not appropriate? These questions need to be further explored.

There are many strategies existing to teach basic math facts to elementary students. The think-addition strategy can be used with students who have mastered their addition facts but who are having difficulty carrying over this knowledge to subtraction facts. When confronted with a subtraction problem, the child would restructure the problem in the form of an addition problem (Poncy, Duhon, Lee, & Key, 2010). For example, 5 – 2 becomes ? + 2 = 5. Fact families are used to assist children with understanding the relationship between addition and subtraction. Fact families consist of the same three numbers that can be arranged in different ways to create two addition and two subtraction facts (May, 1997). For example, the numbers 2, 3, and 5 become 2 + 3 = 5, 3 + 2 = 5, 5 – 2 = 3, and 5 – 3 = 2. These two strategies are taught throughout the *Everyday Mathematics* curriculum, but have not been effective with the "at risk" students in my class to achieve automaticity with basic math facts.

Woodward (2006) studied the integration of strategies for teaching multiplication facts and the use of timed practice drills. These integrated strategies included an introduction to new facts or a review of previously taught facts, the use of number lines and arrays to visualize each fact, and two-minute timed practice drills. The results showed that this integrated approach for teaching math facts helped students better apply the facts to extended facts and estimation than by teaching each strategy in isolation (Woodward, 2006).

The use of technology is another method to teach basic math facts. It includes using computer software consisting of drill and practice, or using computer programs designed to serve as teaching aides so that children can practice math facts independently. An example is Smart toys. Smart toys are described as a computer program designed to respond to a child through microprocessors that recognize and transmit input from a child (Bouck, Bassette, Taber-Doughty, Flanagan, & Szwed, 2009 cited from Roderman, 2002). Another example is the use of the *FLY Pentop Computer (Leapfrog)* to help students practice multiplication facts. Students improved their skills in correctly recalling math facts because the immediate feedback that the computer program provided allowed learners to reduce errors and increase retention of the material (Bouck, Bassette, Taber-Doughty, Flanagan, & Szwed, 2009).

Self-monitoring can also promote automaticity of students learning basic math facts. The self-monitoring process allows students to observe their own mathematics learning and contribute to their feelings of control over their learning (Brookhart, Andolina, Zuza, & Furman, 2004, cited by Covington, 1992). Brookhart and her colleagues (2004) found that students who predicted and graphed their test scores on weekly timed multiplication tests had improved scores over time. Student involvement in their own assessments assisted with the rote memory of learning multiplication facts (Brookhart, Andolina, Zuza, & Furman, 2004).

In reviewing the studies, I have found that more research focused on basic multiplication fact instruction rather than basic addition and subtraction fact instruction. Addition and subtraction are the foundation of basic math skills of elementary school students in the primary grades. At the same time, I found that most studies included students with learning disabilities, but few "at risk" students. These students are "at risk" because they do not respond to less intensive forms of instruction, such as the general education curriculum. Therefore, they are “at risk” of failing (Bryd, 2011).

Significance of the Study

The National Assessment of Educational Progress (2005) showed that 64% of 4^{th} grade students and 70% of 8^{th}-grade students did not demonstrate grade-level competency with mathematics skills (Poncy, Skinner, & Jaspers, 2007 cited from Perie, Grigg, & Dion, 2005). In my teaching experiences, I see children that have not achieved automaticity in learning basic math facts. This problem continues from year to year while their learning gaps become serious. In order to help these “at-risk” students to achieve automaticity in learning math facts, research is needed to examine the effect of different instructional strategies in elementary math instruction.

In this research, two strategies were used to teach “at risk” students basic math facts. The first strategy incorporated technology: the online *Everyday Mathematic*s *Facts Workshop Game*. This online game targets basic skills to allow children to select levels and goals that are appropriate for them. The second strategy incorporated the use of a bar graph for self-monitoring. Students were required to self-manage their performance using a graph to record their scores. The study was valuable in identifying math fact instruction that helped elementary students who are “at risk” achieve automaticity.

Research Questions

This study tried to answer the following questions:

1. Will the use of technology increase automaticity of basic subtraction facts with “at risk” students?

2. Will the use of self-monitoring motivate “at risk” students to improve their math scores to achieve automaticity of basic subtraction facts?

Chapter 2

Literature Review

The ability of elementary students to automatically recall basic addition and subtraction facts is important for their future success in learning mathematics. Basic addition facts consist of one-digit problems ranging from 0 + 0 = 0 to 9 + 9 = 18. Basic subtraction facts consist of the inverse problems and answers from basic addition facts (Poncy, McCallum, & Schmitt, A Comparison of Behavioral and Constructivist Interventions for Increasing Math-Fact Fluency in a Second Grade Classroom, 2010). According to Woodward (2006), automaticity in math facts is fundamental to success in many areas of higher mathematics and without the ability to retrieve facts automatically, students are likely to experience a high cognitive load as they perform more complex tasks. These complex tasks include finding common multiples when adding fractions with unlike denominators, factoring algebraic equations, and estimation (Woodward, Developing Automaticity in Multiplication Facts: Integrating Strategy Instruction with Timed Practice Drills, 2006).

However, current math curriculas emphasize the *acquisition* of basic facts rather than *automaticity* with basic facts (Poncy, McCallum, & Schmitt, A Comparison of Behavioral and Constructivist Interventions for Increasing Math-Fact Fluency in a Second Grade Classroom, 2010). Additionally, because of the growing emphasis on standardized testing mandated by No Child Left Behind (2002), math curricular currently focus on problem solving skills rather than basic calculations. The problem with students who are accurate but slow when responding to basic math facts is that they may become less likely to engage in mathematics, causing them to fall further behind in skill development and limiting their ability to generalize math skills (Poncy, Skinner, & Axtell, 2010 cited by Skinner et al., 2002, 2005). Many students lacking automaticity on basic facts struggle in the math curriculum that emphasizes a problem-solving approach (Codding, Eckert, Fanning, Shiyko, & Solomon, 2007 cited by Gersten & Chard, 1999). Some students do master basic number skills through problem solving, exploration, and discovery, while others require instruction on basic math facts to achieve automaticity (Wong & Evans, 2007 cited by Elkins et al., 2002).

This chapter reviews related research on teaching basic math facts to achieve automaticity. It focuses on students "at risk" in learning basic math facts and instructional strategies, including technology and self-management, to achieve automaticity of learning basic math facts.

Students At Risk in Learning Basic Math Facts

Students at risk are those with learning difficulties and those who have low achievement in math. There are different instructional strategies in teaching these students. Peer tutoring is one strategy used to teach basic math facts. According to Menesses and Gresham (2009), peer tutoring is the process by which a student helps one or more students learn a skill or concept (Menesses & Gresham, 2009 cited from Thomas, 1993). There are two types of peer tutoring: reciprocal peer tutoring (RPT) and nonreciprocal peer tutoring (NPT). RPT is when students alternate between roles of the tutor and the tutee. In NPT, the tutor and tutee remain constant. Menesses and Gresham conducted a study using peer tutoring to teach "at-risk" students basic math facts. The study took place at an elementary school in a large school district in the southeastern part of the United States. Students from seven classrooms were screened using a computer generated curriculum based measurement math probe containing 60 addition, subtraction, multiplication, or division facts depending upon the students' grade level. As a result of the screening, 59 general education students in second, third, and fourth grades participated in the study. Three types of instruction were used to determine which proved most effective in teaching "at-risk" students basic math facts: NPT, RPT, and standard classroom instruction. The three conditions were randomly assigned to classrooms. This resulted in standard classroom instruction being assigned to one second grade classroom and one third grade classroom. NPT was assigned to one second grade classroom, one third grade classroom, and one fourth grade classroom. RPT was assigned to one third grade classroom and one fourth grade classroom. Tutors were individually trained in peer tutoring and an average of three tutoring sessions took place each week for a total of 15 sessions. Sessions were three minutes long and included 10 different math problems presented on index cards. The tutors provided immediate feedback in the form of praise or corrective feedback within 3 seconds of presenting each math problem. Results of the study indicate that both NPT and RPT are comparable in effectiveness and that these two interventions outperformed that of the standard classroom instruction. Additionally, it was found that "at-risk" students being tutored by "at-risk" peers are capable of reaching an average range of performance (Menesses & Gresham, 2009).

Mazzocco, Devlin, and McKenney (2008) studied eighth graders' response accuracy on timed addition and multiplication problems. The performance of 16 children with mathematics learning disabilities (MLD) was compared with 19 children with low math achievement (LA) and 100 typically achieving (TA) children. The researchers compared the errors made by children with MLD during timed math computations to errors made by their peers. They also determined how performance on timed computations varies as a function of how strictly MLD is defined. Students with MLD are often grouped with students with LA into one group. This study differentiated between the two groups. During this study, math facts were grouped into sets of easy and hard problems. A Fast Math Task (FMT) was individually administered to each student. The FMT consisted of 8 pages of 18 math problems involving the same operation (either addition or multiplication). The children were instructed to immediately answer each problem without the use of calculation, as they only had one minute to complete each page. Errors were coded according to different error types for analysis. Results indicate that children with MLD do make more errors on mental calculation problems than their peers. Children with LA make similar errors to those of their typically developing peers. The difference between the students with MLD, students with LA, and typically developing students is that those with MLD perform more poorly on easy problems. Additionally, the results show that math fact difficulties continue past the elementary school years for children with MLD. Only the hard problems separated the LA group from the TA group. Therefore, researchers concluded that the three groups represent moderately deficient, mildly deficient, and typically developing groups of children whose performance profiles differ primarily in the severity of poor performance (Mazzocco, Devlin, & McKenny, 2008).

Teaching Basic Math Facts to Achieve Automaticity

Cover- Copy- Compare (CCC). This is one strategy for teaching basic math fact automaticity. According to Skinner and colleagues (1997), CCC is a self-managed intervention that provides a series of learning trials within a short period of time using five steps: 1) look at the mathematics problem with the answer, 2) cover the mathematics problem with the answer, 3) record the answer, 4) uncover the mathematics problem with the answer, and 5) compare the answer (Codding, Eckert, Fanning, Shiyko, & Solomon, 2007).

A study was conducted by Codding and colleagues (2007) to explore the effects of CCC alone and in combination with performance feedback. Performance feedback includes procedures that provide information to students about their specific academic performance. Three sixth grade students from a large suburban middle school in the northeastern part of the United States participated in the study. These students (two 11 year old females and one 12 year old male) were referred by their teachers for additional services in mathematics. The participants were already receiving instruction on fractions and geometry in an inclusive setting, but were not deemed eligible for special education services. Basic math facts were not part of the classroom instruction at the sixth grade level. A curriculum-based assessment in mathematics in the form of probes was administered to the students to assess their mathematical skills. Skills included in the probes were those recommended by the teachers and included 1x1 digit multiplication, 3x1 digit multiplication with regrouping, 2x2 digit multiplication, 3x3 digit multiplication with regrouping, 3x2 digit addition with regrouping, and 3x3 digit addition with regrouping. Each probe contained 49 problems and post assessments were designed to be slightly more difficult than pre assessments. Throughout the study, participants' performance was assessed using curriculum-based measurement (CBM) probes identified as areas for improvement by the teacher and matching each student's level of instruction. According to Shapiro (2004), CBM is a brief, repeatable method of assessment used to examine the relationship between performance and instruction intervention implemented over a course of time. A random numbers simulation program was used in which the selection and order of problems for each CBM probe was varied. Initially, each probe consisted of 49 problems. As students' rates of responding increased, 15 problems were added. Typed intervention protocols were provided for each of the researchers. The protocols included scripted instructions for each step in each session. The researchers met separately with each of the three students in an empty classroom during a time that did not interfere with regular instruction. The sessions took place three times per week for 16 weeks and lasted for approximately 15 minutes. For the male participant and one of the females, single-digit multiplication was the target skill and three by one digit multiplication with regrouping was the generalization skill. For the second girl, three by two digit addition with regrouping was the target skill and three by three digit addition with regrouping was the generalization skill. Three interventions were administered to each student: 1) CCC, 2) CCC and performance feedback using digits correct per minute, and 3) CCC and performance feedback using digits incorrect per minute. One intervention was implemented per day for an equal number of days and the children were told what intervention they would be using each day. During CCC alone, all students used CCC to practice mathematics facts at their personal instructional levels. If the students' answers did not match the pre-recorded answer, students were to repeat the steps in CCC. During CCC and performance feedback using digits correct per minute, standard CCC steps were administered. The researchers provided the students with feedback regarding the digits they correctly completely per minute from the time prior. The information was presented in the form of a bar graph. The students were encouraged to compute more numbers correctly than they had the session prior. They were then provided with an answer key and instructed to circle the correct digits and make a bar on the graph recording the information. During CCC and performance feedback using digits incorrect per minute, the same procedures were followed as those using digits correct per minute. Since differentiation between treatment conditions was not demonstrated, it is difficult to determine whether adding performance feedback produced better mathematics fluency for the participants than CCC alone. Calculation fluency rates increased across all treatment conditions for each participant, and errors decreased during the intervention phase for the male student and one of the females (Codding, Eckert, Fanning, Shiyko, & Solomon, 2007).

A study conducted by Poncy, Skinner, and Jaspers (2007) compared the effectiveness of CCC to taped problems for teaching automaticity of basic math facts. Taped problems involve a student listening to an audio recording of a person reading a series of math fact problems. The student is to try to write the correct answer before the tape recording provides the answer. If the student incorrectly answers a question, the student is to cross out what they wrote and write the correct answer. If the student does not have enough time to write an answer, he/she is required to do so when hearing it on the tape. The use of immediate feedback provided by CCC and taped problems prevents students from practicing errors and reinforces accurate responding (Poncy, Skinner, & Jaspers, 2007 cited by Skinner & Smith, 1992). A 10 year old girl from a public school in the rural mid-western United States participated in the study. She was diagnosed with moderate mental retardation, having an IQ of 44. Most of her special education services were in a pull-out setting, focusing on basic academic and functional skills. The teacher recommended her for this study to increase her accuracy and automaticity with basic addition facts. The instruction was provided by a special education teacher or school psychologist in the girl's classroom. She was permitted to do an activity of her choice for 5-minutes after each intervention session was complete. Baseline and intervention data were collected using probes consisting of basic addition facts divided into three sets of facts with similar difficulty level. The probes contained 24 problems in six rows of four. The first set of facts was assigned to the CCC intervention, the second set was assigned to the taped problems intervention, and the third set was a control without a treatment intervention. Baseline data was collected for each of the three probe sets during the first four sessions. The student was then trained using both interventions. Afterwards, one intervention was conducted in the morning and the other in the afternoon. Her performance was assessed immediately following each intervention. Every other day, her performance without an intervention was assessed. It was found that immediately following each taped problem intervention, the student accurately responded to single digit addition problems 100% of the time. She accurately responded to problems using CCC 89-100% of the time. Without an intervention, her accuracy remained low, ranging from 27-44%. While both interventions were effective in increasing the student's digits correct per minute, the taped problems were more effective because they required approximately 30% less time to complete (Poncy, Skinner, & Jaspers, 2007).

Further, Bliss and colleagues' study (2010) compared the use of taped multiplication problems with (TP + AIA) and without (TP) a post-treatment assessment. Six fifth-graders, three boys and three girls, were referred by their teacher after being placed in a remedial math class. During the first four sessions, baseline data was collected using assessment sheets where the students had 30 seconds to answer as many problems as possible. On subsequent days, students completed TP after completing a 30 second assessment. During TP, the students listened to a tape playing a series of multiplication problems and answers three times. The students were instructed to try and beat the tape by writing each answer before they heard it on the tape. Each day, instruction alternated between TP and TP + AIA. On the days students were instructed in TP + AIA, they completed an extra assessment sheet immediately following the TP. Individual student data suggests inconsistent results. All students increased in digits correct per minute after both interventions. However, no student showed consistently better performance on either intervention (Bliss, Skinner, McCallum, Saecker, Rowland-Bryant, & Brown, 2010).

In addition, Poncy, McCallum, and Schmitt (2010) compared the effectiveness of CCC to *Facts that Last* (FTL). FTL consists of workbooks designed to increase automaticity and maintenance of basic math facts through individual exploration. The subtraction workbook was used for this study. Nineteen second grade students (11 girls and 8 boys) from a rural elementary school in the Midwestern United States participated in the study. None of the students received special education services in mathematics and the general education curriculum consisted of drill and practice and contextual problems to apply and synthesize mastered skills. The students were expected to complete 64 single digit subtraction problems in 4 minutes (16 correct problems per minute). The assessment and intervention procedures for this study were implemented in the second grade classroom by either the school psychologist or classroom teacher. Both CCC and FTL were implemented daily for 10 consecutive days and maintenance data was collected

2 months post treatment. During the CCC condition, the fact triangle was the focus of instruction. First, students were to look at the fact triangles and then cover it. Then they were to write the problem and answers of the two related subtraction facts, uncover the model and check for accuracy. Each student had 6 minutes to do as many problems as they could. During the FTL condition, fact families were the focus of instruction. Each session began with the teacher introducing a fact family and asking a series of questions related to the part-part-whole relationships. Then, students completed a two page packet and flashcards. Results indicate that CCC led to more gains in digits correct per minute than the FTL treatment for 17 of the 19 students. One student had the same gain in digits correct per minute for both treatments. The other student had a slightly larger gain in digits correct per minute for the FTL treatment than the CCC treatment. Findings indicate that CCC led to more immediate and sustained automaticity with basic subtraction facts than FTL. The fact triangle served as a prompt for students while also providing opportunities for frequent response and immediate feedback (Poncy, McCallum, & Schmitt, 2010).

A similar study by Grafman and Cates (2010) examined the differential effects of Cover, Copy, Compare (CCC) versus Copy, Cover, and Compare (MCCC- modified Cover, Copy, Compare) for teaching subtraction facts. Two second grade classes from middle class suburban schools in the Midwest participated in the study. Participants included a total of 47 students between the ages of 7 and 8 with no noted disabilities. Three sessions totaling 50 minutes was provided to the students in regular education classrooms. Each participant received a timed pretest, a timed CCC worksheet, a timed MCCC worksheet, and a timed posttest. The pretest and posttest consisted of 40 two-digit by one-digit subtraction problems with sums to 18. The problems were the same on both the pre and posttests; however the order of the problems varied. The timed worksheets consisted of 25 subtraction problems similar to those on the pre and posttests. The types of problems being assessed were obtained through teacher recommendations. On the first day of instruction, the students were given two minutes to complete as many problems as they could on the pretest. On the second day of instruction, the CCC and MCCC procedures were explained to the students, and were administered in two minute intervals. On the third day, a posttest was administered. Results indicate that student scores were considerably higher using the CCC treatment than the MCCC.

Detect, Practice, and Repair (DPR). DPR is made up of three phases. In the detect phase, students are given a pretest of fact problems presented in 1.5 second intervals for a total of 72 seconds, then identify the problems that they did not complete. These problems become the targeted problems in the practice phase. In the practice phase, students use CCC procedures to complete the assigned problems. In the repair phase, a one minute drill is administered, and then students graph their own performance. The three phases are intended to promote high rates of responding in order to increase automaticity with math facts.

Poncy and colleagues (2010) incorporated CCC in their research on DPR. A total of 7 third graders, ages 8-10, from the southeastern part of the country were participants. They were recommended by their teacher for difficulty with automatically recalling multiplication facts. Five of the students were girls and two of the students were boys, none of which were receiving special education services. The students had been receiving multiplication instruction using a basal curriculum that focused on problem solving. The teacher also taught multiplication facts by grouping the factors (twos, threes, etc.). Interventions took place in the general education classroom during the first 15 minutes of math each day for 16 days. Assessment probes were made by dividing 36 multiplication problems into three sets of 12 problems. Assessments were administered at the beginning of each math period and after receiving DPR. DPR consisted of a packet of three sheets. The first sheet consisted of 48 problems and was used to detect the problems needed for practice. The second sheet was a CCC sheet and the third was a timed sheet of 48 problems similar to that of the detect sheet. Students recorded the number of problems they completed during the repair phase on a graph. Data suggests that DPR is an efficient method to increase student digits correct per minute because all 7 students made gains and maintained them (Poncy, Skinner, & Axtell, 2010).

Parkhurst and colleagues (2010) used a modified DPR procedure to teach multiplication fact fluency to 10 low achieving 5th grade general education students from an urban school district in the southeastern part of the United States. According to baseline data, six of the students were at the instructional level and four were at the frustration level. Three sets of 12 problems were created and included 1 digit by 1 digit multiplication problems. Three Microsoft PowerPoint slide shows with 15 slides were created for each set of problems. The slide show was designed so that each problem (1 per slide) appeared for 3 seconds. The final slide was an answer key, providing answers to the 12 problems in the slide show. During the intervention, students were given intervention sheets. The slide show was displayed on a Smart Board and students were to write the correct answer to each math fact before a new problem was displayed. Following the slide show, the students were asked to evaluate their work and identify the first five problems that they did not answer correctly. Students used CCC to practice problems they did not answer correctly within 3 seconds. Baseline data was around 28-30 digits correct per minute. After the intervention, there was an increase in digits correct per minute for the first two sets. The largest increase was for the second set. Two students that were at the instructional level improved by over 20 digits per minute. Six students improved by an average of 9 digits per minute. The third set of data was invalid because the students randomly wrote down answers. The research indicated that technology enhances automaticity when used to identify math facts that need to be mastered (Parkhurst, Skinner, Yaw, Poncy, Adcock, & Luna, 2010).

Explicit Instruction. Explicit instruction is the use of modeling, prompting, and frequent checking of student progress during instruction; therefore, students are able to maintain high levels of accuracy when learning new tasks. Lee and colleagues (2005) studied the use of explicit instruction to teach multiplication facts. The research was designed to present problems of high probability of completion (high-p) prior to a task with a low probability of completion (low-p). Three female students receiving special education services participated in the study and were referred by their teacher due to a history of difficulty in learning basic math facts. Three students were participants: one 11 year old with an IQ of 71, diagnosed with mild mental retardation, the other two, 10 years old, diagnosed with a specific learning disability with IQs of 98. They received mathematics instruction in a resource room at a public school in a large urban district in Eastern Pennsylvania. A pre-assessment was administered using single digit addition and single digit multiplication problems. The students were presented with basic addition and multiplication facts on index cards. If the students answered a fact correctly in 2-3 seconds, the fact was considered mastered. If the student answered incorrectly during that time, the fact was considered unknown. Multiplication facts were assigned to either a traditional explicit instruction (EXPL) pool or EXPL plus high-p pool. Then, the facts were divided into one of three sets. The first set contained 5 EXPL problems and 5 EXPL plus high-p problems with unknown facts. The second and third sets contained 3 EXPL problems and 3 EXPL plus high-p problems. Unknown facts were modeled, prompted, and checked twice within each condition. Following instruction, students completed a fact acquisition worksheet consisting of problems from one of the sets. The facts answered correctly were considered mastered and removed from the instructional materials. Traditional EXPL resulted in faster acquisition of facts for the 11 year old student on all three sets of math facts. It took her 3 sessions to master the set one facts using EXPL and 11 sessions to master the facts using the EXPL plus high-p condition. The two 10 year olds benefitted more from the EXPL plus high-p condition for sets one and two. Based on the data, both interventions were equally effective (Lee, Stansbery, Kubina, & Wannarka, 2005). It appears that explicit instruction with teacher modeling, questioning, and frequent checking for understanding and practices help students with disabilities in learning math facts.

Timed Practice. Woodward (2006) studied the integration of strategy instruction with timed practice drills to help students develop automaticity with multiplication facts. Participating students included 58 fourth graders from two classrooms in a suburban school district in the Pacific Northwest. According to the Math Computations portion of the Iowa Test of Basic Skills, these students were approximately one year behind grade level at the beginning of the study. Fifteen of the 58 students were diagnosed with learning disabilities, but all of the students were of normal intelligence. Thirty of the students were assigned to the intervention group, including 8 students with learning disabilities. Twenty-eight students were in the control group, including 7 students who had learning disabilities. The students in both groups were taught using timed practice drills for 25 minutes per day, five days a week, for four weeks. The intervention was conducted in three phases. In the first phase, the students were introduced to new fact strategies or a review of previously taught fact strategies. Number lines or arrays were displayed on the overhead projector and children could visualize each strategy and compare with previously learned strategies. In the second phase, a 2 minute timed practice drill was administered. Afterwards, the teacher dictated the answers to the facts and the students corrected their own work. Automaticity was monitored. When 70% of the students achieved 90% correct on a strategy, the teacher taught the next strategy. In the third and final phase, daily instruction included teaching the relationship between facts and extended facts. The control group also received three phases of instruction. In the first phase, the students were introduced to new fact strategies or a review of previously taught fact strategies. In the second phase, a two minute timed practice drill was administered. Afterwards, the teacher dictated the answers to the facts and the students corrected their own work. Automaticity was monitored. When 70% of the students achieved 90% correct on a strategy, the teacher taught the next strategy. In the third phase, a practice worksheet was distributed with computational problems consisting of 3 by 2 digit and 2 by 2 digit multiplication. These problems involved only the facts that had been taught up to that point in the study. The teacher modeled how to solve those types of problems using a traditional multiplication algorithm. Results of the study showed that both methods were effective in raising basic math facts to mastery or near mastery levels. Additionally, both groups improved in their knowledge of harder multiplication facts. Since the study was only conducted for a four week period, neither group achieved mastery of the harder multiplication facts. It was noted that the difference of performance levels between students with and without learning disabilities posed a challenge of moving all students in a classroom forward as the same time. While all students improved from pre to posttest, the students with learning disabilities remained behind their peers. The integrated students had the opportunity to discuss basic facts and extended facts. Therefore, their performance in this area was higher than that of the timed practice only group. However, students in the timed practice only group had more opportunities to practice 3 by1 digit and 2 by 2 digit multiplication problems using the traditional algorithm. Therefore, their performance in this area was higher than that of the integrated group (Woodward, Developing Automaticity in Multiplication Facts: Integrating Strategy Instruction with Timed Practice Drills, 2006).

In another study, Beveridge and colleagues (2005) used math racetracks to teach math facts to two elementary students (1 boy in third grade and 1 boy in sixth grade) with learning disabilities attending a large Department of Defense elementary school in the Pacific Northwest. The boys were recommended for the study because of their low math skills. A math racetrack consists of drill and practice with facts arranged on a sheet of paper in the shape of an oval racetrack. The boys were put on a reward system where each boy could earn a small bag of candy for improving their time on the math racetrack or after they showed they worked to the best of their ability. During the intervention, which lasted for 10 sessions, the boys were given a racetrack with a mix of seven problems they did not know and the rest of the problems were problems they knew. There were a total of 28 problems. Each participant had three different racetracks with the same 21 problems they had mastered and the 7 problems they needed to learn. The boys were timed and a maximum of 5 seconds was given to complete each problem. If a problem was answered incorrectly or if the student was unable to solve a problem in the 5 seconds allotted, then the correct answer was provided. Results indicated that the number of problems answered correctly during math racetrack increased overall during the course of the intervention. While the Math Racetrack was shown to be effective, a longer term of study would need to collect data to support the findings (Beveridge, Weber, Derby, & McLaughlin, 2005).

Using Technology in Teaching Basic Math Facts

An area of expanding research for helping students achieve automaticity with basic math facts is the use of technology. Bouck and colleagues (2009) used Pentop computers by Leapfrog as tools for teaching multiplication to three middle school students with mild intellectual disabilities. The students received mathematics instruction in a self-contained classroom by a special education teacher. Prior to the intervention, the students were assessed on multiplication facts learned through traditional instructional methods two or three times a week. During the intervention, student learning of one and two digit multiplication facts was assessed over a 3 week period after using a Pentop computer to practice multiplication facts. As the students wrote multiplication problems, the software immediately repeated the numbers aloud. Students solved the problems using the algorithm specified by the FLY Pen. If an error was made, the FLY Pen would give a hint about where the error was made. After practicing with the Pentop computer in class, the students were assessed on ten multiplication facts three to four times per week without the use of the Pentop computer. The results of the study indicate that all three students improved in the percentage of correct math facts completed, supporting the use of the Pentop computer for teaching basic multiplication facts to students with mild intellectual disabilities (Bouck, Bassette, Taber-Doughty, Flanagan, & Szwed, Pentop Computers as Tools for Teaching Multiplication to Students with Mild Intellectual Disabilities, 2009).

A study conducted by Wong and Evans (2007) compared the use of pencil and paper for teaching multiplication facts to the use of computers. Thirty-seven fifth graders from four inner-city schools in Sydney, Australia formed the computer-based instruction group. Twenty-seven students from the same grade formed the pencil and paper instruction group. Basic multiplication fact recall was measured by the number of multiplication facts answered correctly in one minute. The pre and posttests as well as the maintenance tests containing 60 problems from the 0 to 10 times tables in random order were used to evaluate student performance. The computer software selected was Back to Basics Math Multiplication, allowing the students to select the tables to be practiced at each session. Eleven practice sessions were conducted in four weeks. The sessions lasted 15 minutes with each students receiving multiplication practice using either computer-based instruction or pencil and paper exercises in the form of worksheets. During each session, four sets of multiplication tables were practiced, interspersing new and previously practiced facts. Students were found to have mastered facts after correctly answering a question three times in a row. Results of the study do not support the idea that computer-based instruction is more effective than traditional pencil and paper practice approaches. A possible explanation for the results being similar could be that the writing practice received by the pencil and paper group may have contributed to their ability to write faster and with their familiarity with the posttest format (Wong & Evans, 2007).

Self-management to Promote Student Automaticity in Learning Basic Math Facts

Brookhart and colleagues (2004) used Minute Math with students to help them self-assess their progress with multiplication facts. Participants included 41 students in two third grade classes from a suburban elementary school in the eastern United States. The students included both regular and special education students. In each class, 5 minute timed multiplication fact tests with 100 problems were given once a week for 10 weeks. Classroom instruction during that time included practice with the times tables and with strategies for learning them. Each week, students were given a prediction exercise prior to taking the test. The students predicted their performance and graphed it on a bar graph. When the results of their test were returned, the students graphed their actual score next to their predicted score. They used a reflection sheet to write whether or not they had met their goal, what strategy they used and how well it worked, and what strategy or strategies they planned to use for the next week. On average, students in both classes predicted their achievement very well. The overall average in Class 1 rose over the 10 weeks and on average the predictions were accurate. As time went on, students got more accurate in their predictions. The overall average in Class 2 also rose over the 10 weeks. At the beginning of the intervention, overpredictions were made, but narrowed over time. Students attributed their success to practice and memory. About 70% of the students used either one strategy or a few strategies consistently throughout the duration of the study. The other 30% of the students used a variety of strategies, switching from week to week. The study suggests that student involvement in their own assessment can add reflection to rote memory tasks (Brookhart, Andolina, Zuza, & Furman, Minute Math: An Action Research Study of Student Self-Assessment, 2004).

Poncy and colleagues (2010) studied techniques to promote automaticity with basic math fact skills through the use of a combination of strategies. Three fourth grade general education students, two girls and one boy, from a public school in northeast Oklahoma participated in the study. They were referred by their teacher for poor performance with basic math facts. The teacher noted that the students could accurately complete addition and subtraction facts using counting strategies, but they lacked automaticity with the facts. Baseline data was collected using three sets of problems. The first set contained 12 addition problems, the second set contained 12 related subtraction problems, and the last set served as a control containing 12 unrelated subtraction problems. The students had one minute to solve each set of problems. Following the baseline, an assessment packet was distributed each day with three probes consisting of 48 problems each. The problems mirrored those in the problem sets used to collect baseline data. A combination of goal setting, explicit timing, and performance feedback with a reward was used. To increase digits correct per minute, each student was informed of the previous day's score and encouraged to beat it. The students were given 4 minutes to complete as many problems as they could on a series of intervention sheets. Performance feedback was immediately provided. If a student beat his/her score from the previous day, he/she would be rewarded with a pencil or eraser. As students' digits correct per minute on the first set of addition problems increased, data on the subtraction facts for the second two sets was collected to examine the possible generalization. Once the students reached mastery (approximately 40 digits correct per minute) of the addition problems from the first set of problems, a conceptual lesson was introduced. This phase focused on the part-part-whole relationship and the think-addition strategy, enabling them to use their prior knowledge of addition facts to help solve subtraction facts. Students who failed to increase the number of digits correct per minute on the second set of subtraction problems were introduced to the cloze procedure. Cloze fact problems provided an answer but withheld the first addend, reinforcing the think-addition strategy. The results showed that the introduction of the fluency phase through goal setting resulted in an increase of digits correct per minute on the addition set of problems for all of the three students. The first student demonstrated an increase in digits correct per minute following the first two interventions. However, the student's performance eventually leveled out. The second student showed improvement across all three intervention phases. The third student showed an increase in digits correct per minute after the first phase, but leveled out for the second two phases. While this study was effective in increasing students' digits correct per minute, it did not succeed in helping students generalize their known addition facts to related or unrelated subtraction facts (Poncy, Duhon, Lee, & Key, 2010).

Summary

After reviewing the literature and my own personal practice in the classroom, I continue to find ways to help the "at risk" students in my second grade class to achieve automaticity with basic addition and subtraction facts. The interventions that I implement need to be conducted so that they do not interfere with the rest of the class and fall into the time constraints of my 60 minute math period. A majority of the research focuses on helping students in third grade and beyond achieve automaticity with multiplication facts. However, without learning to add and subtract, the task of multiplication (or repeated addition) will not be possible.

In this study, I focused on 4 students in my second grade general education classroom who have yet to achieve automaticity with basic addition and subtraction facts. Previously, I used daily timed math drills grouped according to addend to help teach math facts. The students individually checked their answers after each session and practiced the same facts for their homework. Building on the research of Woodward (2006) and others, this study provided students with technology in the form of a computer program to practice their facts, timed practice drills to help students develop automaticity with subtraction facts, and the opportunity to monitor their progress using a bar graph. The combination of these strategies was implemented with the "at risk" students in my class to determine if it met their need to achieve automaticity with basic subtraction facts.

Chapter 3

Methods

Setting

School and Community. This study took place in an elementary school in a small suburban community in southern New Jersey. The elementary school was one of the three in the district, built in the 1960's. There were approximately 175 students in the school from grades kindergarten to sixth. There was one class per grade with the exception of second grade, which had two classes due to an increased enrollment. Students with disabilities were placed in inclusion classrooms, but the school also housed a classroom for students with severe disabilities. The school district's District Factor Group (DFG), which measures the community's relative socioeconomic status, was "GH" on a scale from "A" (poorest) to "J" (wealthiest). That means that the school was located in a middle/upper middle class community.

Classroom. The study took place in one of the second grade classrooms. There were 18 general education students in the classroom and a parallel co-teaching model was used to teach mathematics by two teachers. The classroom teacher had eight years of experience teaching students from grades pre-kindergarten through sixth. She was a math specialist for three years prior to becoming a second grade teacher and she held a certification in special education. The math specialist had three years of experience in teaching math in New Jersey, but had prior teaching experience in another state. The classroom teacher and the math specialist taught daily lessons to one of two groups on a rotating basis. The students were grouped according to their ability. The small group contained four students who were "at risk" of failure in mathematics. The large group contained the 14 remaining students. A Smartboard was used to enhance instruction and there were two computers available for students.

Participants

Students. Four "at-risk" second graders participated in the study. Student 1 was an eight year old male who was retained in first grade due to low academic achievement in all subject areas. After repeating first grade, he met grade level benchmarks for language arts but still exhibited weaknesses in mathematics, particularly with automatic recall of basic math facts. During timed tasks, he wrote down random answers.

Student 2 was a seven year old female who exhibited delays in mathematics across various domains. She had very poor number sense, difficulty identifying and interpreting place value, and was heavily reliant on the number grid for basic computation. Her automatic recall of basic math facts was poor. When a number grid was not accessible, she used her fingers to add and subtract. Her report card grades for the first and second marking periods were "in need of improvement". The Intervention and Referral Services (I&RS) team had met to brainstorm and implement interventions to help her become more successful in the math classroom. Recommendations by the team were currently being implemented to include out of school tutoring two times per week, small group instruction within the classroom, an added review component to homework each evening, and extended time as necessary for testing.

Student 3 was an eight year old male who was very shy and was almost non-verbal throughout first grade. While his reading skills were rather low, his math performance was age appropriate. However, most tasks took him very long to complete and, therefore, his ability to automatically recall basic math facts was poor. He had just been evaluated by the speech and language pathologist in the area of articulation and became eligible for speech services.

Student 4 was a seven year old female, the youngest in the class. Her math performance was age appropriate; however, her ability to automatically recall basic math facts was poor. She exhibited frustration during timed fact tests, especially when she compared her performance to that of her peers. Table 1 provides general information about participating students.

Table 1.

General Information of Participating Students

Student	Gender	Age	Mixed Addition Fact Test (0-5)	Mixed Addition Fact Test (6-9)
1	M	8.7	48%	47%
2	F	7.10	52%	77%
3	M	8.4	65%	82%
4	F	7.7	87%	56%

Teachers. Each math lesson was taught by the classroom teacher and the math specialist in a co-teaching format. The lessons lasted approximately 50 minutes each day following approximately 10 minutes of fact instruction by the classroom teacher.

Materials

Instructional Materials. The second grade general education math curriculum was *Everyday Mathematics*, *Common Core Edition* by McGraw-Hill (2012). Developed by the University of Chicago School Mathematics Project, this research based program has a spiral design where concepts are introduced and then revisited throughout the year to help students achieve mastery. The students continued to be instructed following this curriculum throughout this study. The allotted instructional time for mathematics was 60 minutes per day, five days a week. The study took place during this time frame.

Measurement Materials. Five teacher made assessments (A-E) were developed, and each consisted of 60 subtraction facts that were required to be completed in three minutes. All assessments were designed to start and end with an "easy" math fact to promote confidence. Problems were set up in six rows of ten problems. Assessment A included subtraction problems randomly assigned containing subtrahends of 0, 1, and 2 and their corresponding subtraction fact from each fact family. (For example: 8 – 1 = 7 and 8 – 7 = 1) It also included subtraction facts containing doubles. (For example: 8 – 4 = 4 and 10 – 5 = 5) Assessment B included subtraction problems randomly assigned containing subtrahends of 4 through 9. Assessment C included subtraction problems randomly assigned containing subtrahends of 3 through 9. Assessment D included subtraction problems randomly assigned containing corresponding subtraction facts from assessment C. (For example: 10 – 4 = 6 becomes 10 – 6 = 4) Assessment E included a selection of subtraction problems from assessments A-D randomly assigned (see Appendices A-E for examples).

Software Package. The revised edition of *Everyday Mathematics* has an online component called the Facts Workshop Game. The game, which can be accessed at www.everydaymathonline.com, was used for students to practice basic facts. It emphasizes addition and subtraction fact families through the use of fact triangles and dominos. Students were able to advance through levels of varying difficulties and collect awards for their in-game achievements. At the same time, their progress through an online teacher management system was monitored.

Self-monitoring. A bar graph was used for students to self-monitor their daily performance by plotting data. It consisted of five separate graphs (A-E) that corresponded to the timed subtraction tests (A-E) administered daily. Students were required to graph the number of correct answers obtained each day (see Appendix F).

Research Design

A single subject research design with A B C phases was used. During Phase A, the participating students were given five timed subtraction tests in five days. Their scores were recorded as baseline data. During Phase B, the first intervention period, these students were taught basic addition and subtraction facts using the *Everyday Mathematics* online Facts Workshop Game over a five week period. During Phase C, the second intervention period, the students self monitored their progress in conjunction with the *Everyday Mathematics* online Facts Workshop Game. Phase C lasted for another five weeks. Student scores at the end of Phase C were compared with baseline data from Phase A in order to measure their gains.

Procedures

This study took place over 11 weeks and was conducted by the classroom teacher.

Measurement Procedures. The first week (Phase A) consisted of collecting baseline data using five teacher made assessments (A-E). When an assessment was given, the students were instructed to put their name and date at the top of their paper. They were told to do the ones they knew first. If they made a mistake, they should not erase, but rather cross out the incorrect number and write the correct number. When everyone was ready to begin, the teacher said, "Ready, Set, Begin." After every minute, the teacher gave a time update. After the first minute, the teacher said, "One minute, two to go." After the second minute, the teacher said, "Two minutes, one to go." At the end of three minutes, the teacher said, "Stop, pencils down." Then, the children took out marking pens and as the teacher read the problems and answers, the children marked their work. If a problem was correct, they left it alone. If a problem was incorrect, they wrote the correct answer in pen. If a problem was left blank, they filled in the correct answer in pen. This measurement procedure was also followed throughout Phases B and C.

Instructional Procedures. During weeks two through six (Phase B), students used the *Everyday Mathematics* online Facts Workshop Game. Each student played for 5 minutes a day prior to being given a three minute fact test. A multiple baseline research design was used so that Student 1 had five days of game play before Student 2 gained access. Student 2 had five days of game play before Student 3 gained access, etc. On the first day that each student gained access, the teacher showed the students how to log in using their individual username and passwords (posted on a bulletin board by each computer). Game play was explained. There was also a built in tutorial in the game if the students had further questions. From then on, students used their own personal login information to access the online game independently. A timer was set for 5 minutes to monitor the length of game play. Once everyone had 5 minutes of game play, fact tests were administered. Timed fact tests were identical to those from the baseline data (A-E) and were administered on a rotating basis in order throughout the duration of Phase B. The same procedure for administration was used in Phase B as was used in Phase A (see Appendix G for an example of instruction).

During weeks seven through eleven (Phase C), students used the *Everyday Mathematics* online Facts Workshop Game in conjunction with self-monitoring. Each student played the game for 5 minutes a day prior to being given a three minute fact test. Timed tests were identical to those of Phases A and B and were administered on a rotating basis in order and in the same manner throughout the duration of Phase C. A multiple baseline research design was used so that Student 1 self-monitored for three days before Student 2 began self-monitoring. Student 2 self-monitored for three days before Student 3 began self-monitoring, etc. The students graphed the number of problems solved correctly on each day's fact test. They used a colored pencil to fill in the data. The graph they used corresponded to the letter of the timed test. For example, assessment A results got graphed on Graph A, assessment B results got graphed on Graph B, etc. (see Appendix H for an example of instruction).

Data Analysis

Students' scores on assessments at the end of each phase were recorded in a graph and compared to baseline data of Phase A. Particular attention was given to determine which intervention was effective. Did the use of technology alone increase students' correct responses or the combination of technology and self-monitoring produce more gains? Each student's performance was recorded and graphed to demonstrate their progress.

Chapter 4

Results

Participating students' performance was evaluated by ongoing assessments in math class. Students were given 3 minutes to solve 60 subtraction problems each day. Baseline data was collected using assessments A-E for 5 days. During the first intervention, which lasted five weeks, students used technology to practice basic facts and data was collected using assessments A-E. During the second intervention, which also lasted five weeks, students used self-monitoring and data was collected using assessments A-E. The number of correct responses on each assessment was recorded. Figures 1 and 2 present the individual student scores.

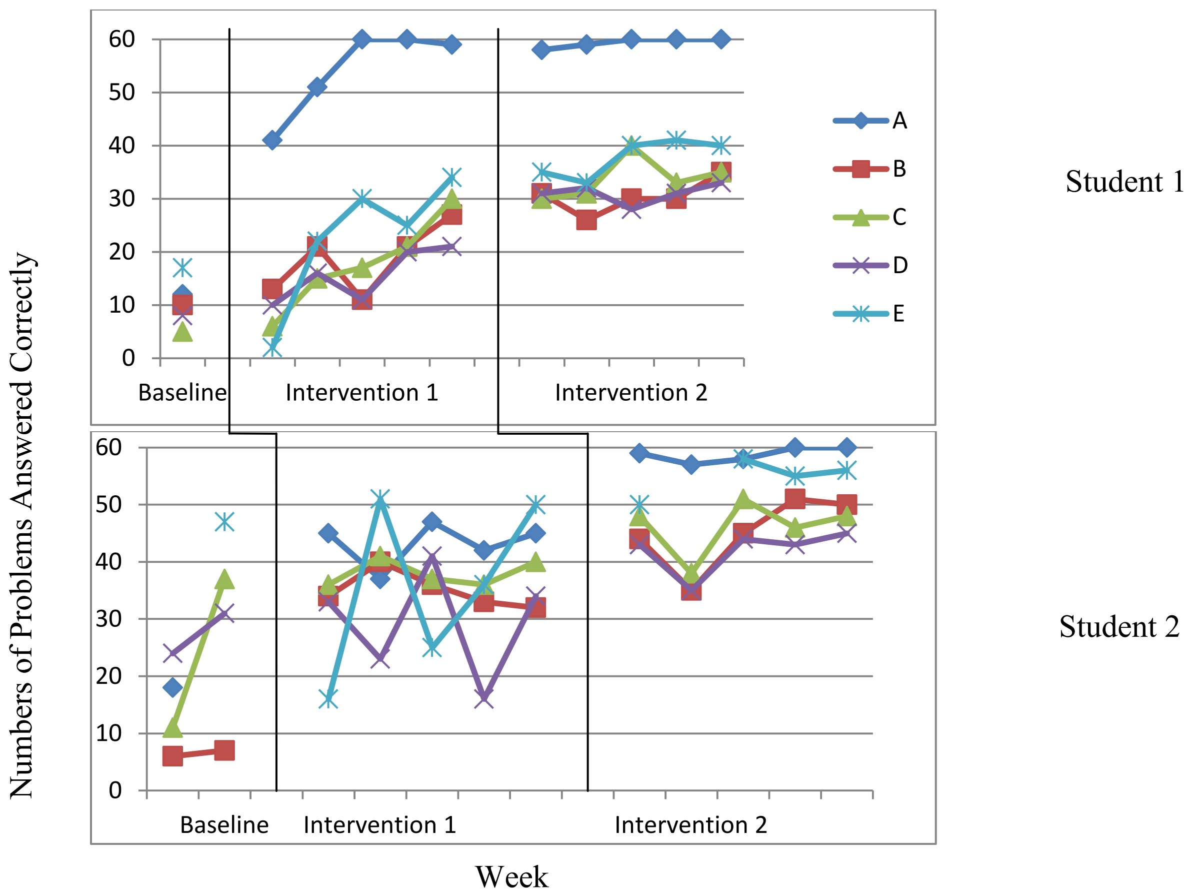


Figure 1. Student 1 and student 2's math performance.

Student 1 scored an average of 10 problems correctly on baseline assessments. During the first intervention, he scored an average of 26 problems correctly. During the second intervention, he scored an average of 38 problems correctly.

Student 2 scored an average of 23 problems correctly on baseline assessments. During the first intervention, she scored an average of 36 problems correctly. During the second intervention, she scored an average of 49 problems correctly.

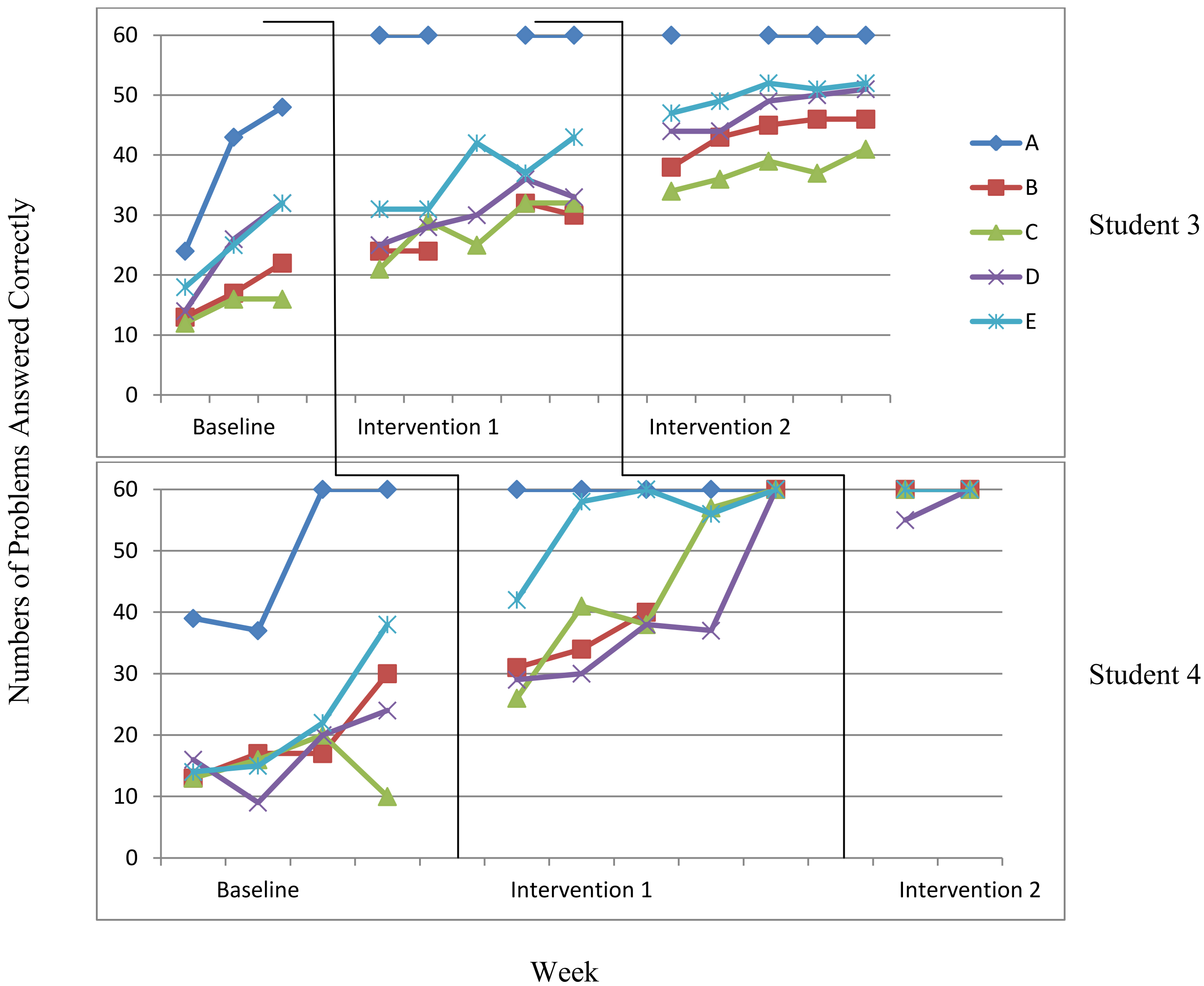


Figure 2. Student 3 and student 4's math performance.

Student 3 scored an average of 24 problems correctly on baseline assessments. During the first intervention, he scored an average of 36 problems correctly. During the second intervention, he scored an average of 47 problems correctly.

Student 4 scored an average of 25 problems correctly on baseline assessments. During the first intervention, she scored an average of 48 problems correctly. During the second intervention, she scored an average of 60 problems correctly. Because she obtained a perfect score on five consecutive assessments (A-E) during the second week of the second intervention, no further assessments and interventions were provided.

Chapter 5

Discussion

Findings

This study sought to answer two questions. The first question investigated whether or not the use of technology would increase automaticity of basic subtraction facts with "at risk" students (intervention 1). The second question investigated whether or not self-monitoring would motivate "at risk" students to improve their math scores to achieve automaticity of basic subtraction facts (intervention 2).

The technology intervention yielded an average increase of 16 problems correct across all four students (with an increase ranging from 12-23 problems correct) as compared to baseline data. This improvement in automaticity with basic facts after using technology is consistent with findings from the previous research.

Bouck and colleagues (2009) used Pentop computers by Leapfrog as tools for teaching multiplication to three middle school students with mild intellectual disabilities. After practicing with the Pentop computer in class, the students were assessed on multiplication facts three to four times per week without the use of the Pentop computer. The results of the study indicate that all three students improved in the percentage of correct math facts completed, supporting the use of technology for teaching basic facts to students with mild intellectual disabilities (Bouck, Bassette, Taber-Doughty, Flanagan, & Szwed, Pentop Computers as Tools for Teaching Multiplication to Students with Mild Intellectual Disabilities, 2009).

The self-monitoring intervention yielded an average increase of 12 problems correct across all four students (with an increase ranging from 11-13 problems correct) as compared to data from the first intervention. This improvement in automaticity with basic facts after using self-monitoring is consistent with findings from the previous research.

Poncy and colleagues (2010) studied techniques to promote automaticity with basic math fact skills through the use of a combination of strategies. A combination of goal setting, explicit timing, and performance feedback was used. To increase digits correct per minute, each of three students was informed of the previous day's score and encouraged to beat it. The students were given 4 minutes to complete as many problems as they could on a series of intervention sheets. Performance feedback was immediately provided. The results showed that the introduction of goal setting and performance feedback resulted in an increase of digits correct per minute for all of the students (Poncy, Duhon, Lee, & Key, 2010).

Although both technology and self-monitoring were successful in promoting basic fact acquisition, it is difficult to say which intervention was more effective. There were fewer gains in average problems correct during the second intervention, self-monitoring. However, overall, there was less room for improvement because there was only a total of 60 possible points on each assessment.

Limitations

There were several limitations to this study. Classroom management and time were the first limitations. Even though the interventions and assessments theoretically took ten minutes per day, it was difficult to implement the study with the small group of students while managing the other members of the class. Additionally, there were only two fully functioning computers in the classroom. Thus, it took twice as long to rotate all four students through for the technology intervention. Because the allotted math time is 60 minutes, it was necessary to take time from another subject to make sure that there was enough time to conduct the research with integrity while also covering the mandated instructional materials to follow the required math curriculum.

A second limitation of this study was attendance. Not all of the participating students were present 100% of the time. There were a total of eight absences by all four students in the 11 week period. While students still showed improvement in problem solving with correct responses across the duration of the study, it is not known if there would have been a greater improvement had there not been lapses in the intervention due to absences.

Implications

The results of this study support the use of technology in teaching basic math facts to "at risk" students. However, there are a number of general education students that also require additional support in learning basic facts and who could benefit from this approach. Therefore, the use of technology should become part of the math curriculum for all students. This study also supports self-management to promote student automaticity in learning basic math facts. Teachers need to take the time to communicate with individual students, help them set personal goals, and assist them in self-monitoring their progress.

Conclusions and Recommendations

If this study were to be conducted again, a larger math block would be needed to implement the interventions effectively and to follow the mandated curriculum. Additionally, greater computer access would need to be provided. As a follow up to this study, I plan to send students home with their usernames and passwords to access the Facts Workshop Game website so that they can continue practicing basic facts. In the future, I plan to implement technology and self-monitoring will all students, not just those deemed “at risk”. Finally, I plan to share the results of this study with administrators in the hopes of obtaining more classroom computers for future implementation.

References

Beveridge, B. R., Weber, K. P., Derby, K. M., & McLaughlin, T. (2005). The Effects of a Math Racetrack with Two Elementary Students with Learning Disabilities. *The International Journal of Special Education* , 58-65.

Bliss, S. L., Skinner, C. H., McCallum, E., Saecker, L. B., Rowland-Bryant, E., & Brown, K. S. (2010). A Comparison of Taped Problems With and Without a Brief Post-Treatment Assessment on Multiplicaton Fluency. *Journal of Behavioral Education* , 156-168.

Bouck, E. C., Bassette, L., Taber-Doughty, T., Flanagan, S. M., & Szwed, K. (2009). Pentop Computers as Tools for Teaching Multiplication to Students with Mild Intellectual Disabilities. *Education and Training in Developmental Disabilities* , 367-380.

Brookhart, S. M., Andolina, M., Zuza, M., & Furman, R. (2004). Minute Math: An Action Research Study of Student Self-Assessment. *Educational Studies in Mathematics* , 213-227.

Bryd, S. E. (2011). Educating and Involving Parents in the Response to Intervention Process. *Teaching Exceptional Children* , 32-39.

Codding, R. S., Eckert, T. L., Fanning, E., Shiyko, M., & Solomon, E. (2007). Comparing Mathematics Interventions: The Effects of Cover-Copy-Compare Alone and Combined with Performance Feedback on Digits Correct and Incorrect. *Journal of Behavioral Education* , 125-141.

Lee, D. L., Stansbery, S., Kubina, R., & Wannarka, R. (2005). Explicit Instruction With or Without High-p Sequences: Which is More Effective to Teach Multiplication Facts? *Journal of Behavioral Education* , 267-281.

May, L. (1997, November/December). Mastering Addition and Subtraction Facts. *Teaching K-8* , p. 14.

Mazzocco, M. M., Devlin, K. T., & McKenny, S. J. (2008). Is it a Fact? Timed Arithmetic Performance of Children with Mathematical Learning Disabilities (MLD) Varies as a Function of How MLD is Defined. *Developmental Neuropsychology* , 318-344.

Menesses, K. F., & Gresham, F. M. (2009). Relative Efficacy of Reciprocal and Nonreciprocal Peer Tutoring for Students At-Risk for Academic Failure. *School Pyschology Quarterly* , 266-275.

Parkhurst, J., Skinner, C., Yaw, J., Poncy, B., Adcock, W., & Luna, E. (2010). Efficient Class-wide Remediation: Using Technology to Identify Idiosyncratic Math Facts for Additional Automaticity Drills. *Behavior Analyst Online* , 111-123.

Poncy, B. C., Duhon, G. J., Lee, S. B., & Key, A. (2010). Evaluation of Techniques to Promote Generalization with Basic Math Fact Skills. *Journal of Behavioral Education* , 76-92.

Poncy, B. C., McCallum, E., & Schmitt, A. J. (2010). A Comparison of Behavioral and Constructivist Interventions for Increasing Math-Fact Fluency in a Second Grade Classroom. *Psychology in the Schools* , 917-930.

Poncy, B. C., Skinner, C. H., & Axtell, P. K. (2010). An Investigation of Detect, Practice, and Repair to Remedy Math-Fact Deficits in a Group of Third-Grade Students. *Psychology in the Schools* , 342-353.

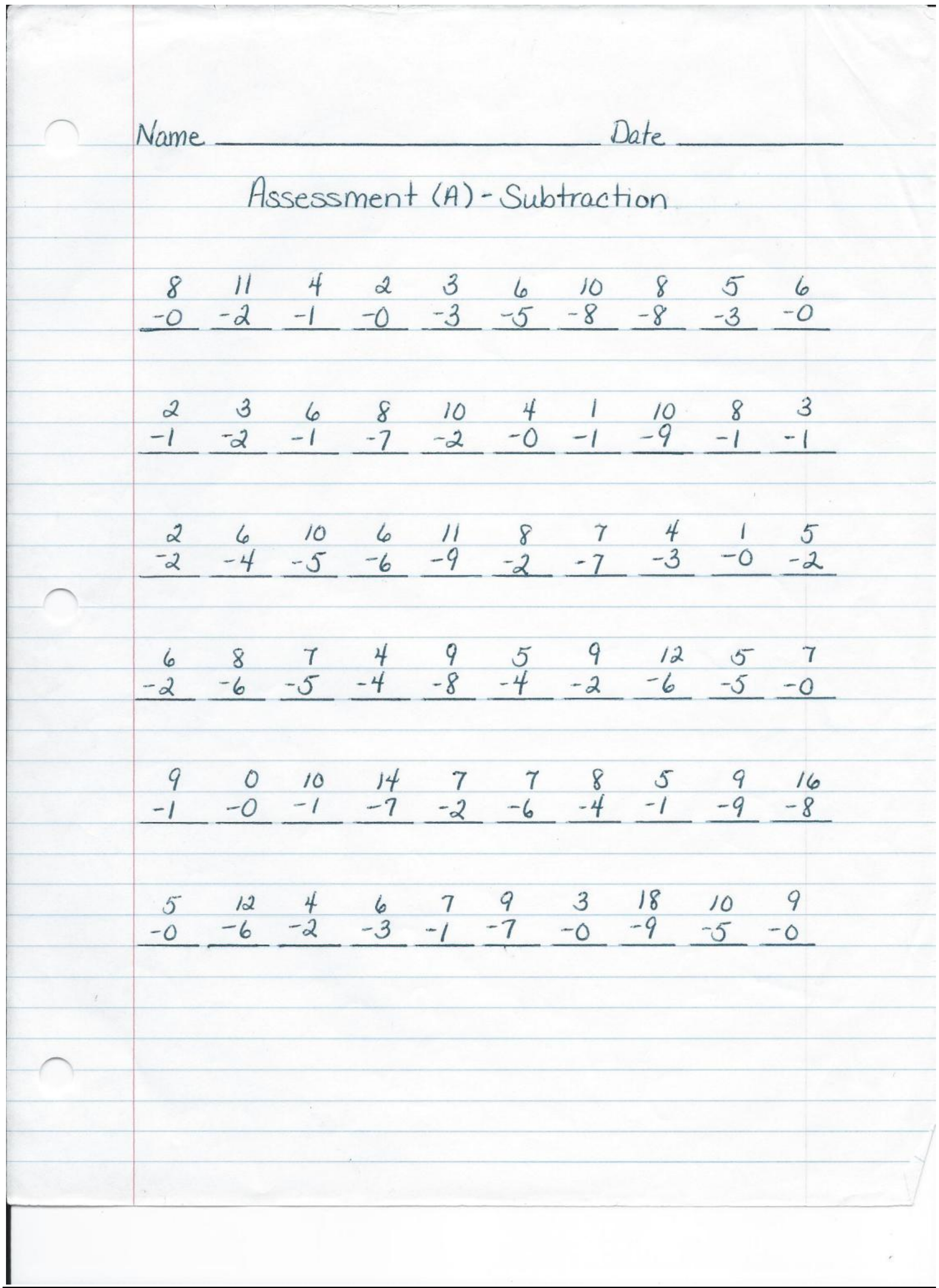
Poncy, B. C., Skinner, C. H., & Jaspers, K. E. (2007). Evaluating and Comparing Interventions Designed to Enhance Math Fact Accuracy and Fluency: Cover, Copy, and Compare Versus Taped Problems. *Journal of Behavioral Education* , 27-37.

Wong, M., & Evans, D. (2007). Improving Basic Multiplication Fact Recall for Primary School Students. *Mathematics Education Research Journal* , 89-106.

Woodward, J. (2006). Developing Automaticity in Multiplication Facts: Integrating Strategy Instruction with Timed Practice Drills. *Learning Disability Quarterly* , 269-289.

Appendix A

Assessment A



Name ______________________ Date __________

Assessment (A) - Subtraction

8	11	4	2	3	6	10	8	5	6
-0	-2	-1	-0	-3	-5	-8	-8	-3	-0
2	3	6	8	10	4	1	10	8	3
-1	-2	-1	-7	-2	-0	-1	-9	-1	-1
2	6	10	6	11	8	7	4	1	5
-2	-4	-5	-6	-9	-2	-7	-3	-0	-2
6	8	7	4	9	5	9	12	5	7
-2	-6	-5	-4	-8	-4	-2	-6	-5	-0
9	0	10	14	7	7	8	5	9	16
-1	-0	-1	-7	-2	-6	-4	-1	-9	-8
5	12	4	6	7	9	3	18	10	9
-0	-6	-2	-3	-1	-7	-0	-9	-5	-0

Appendix B

Assessment B

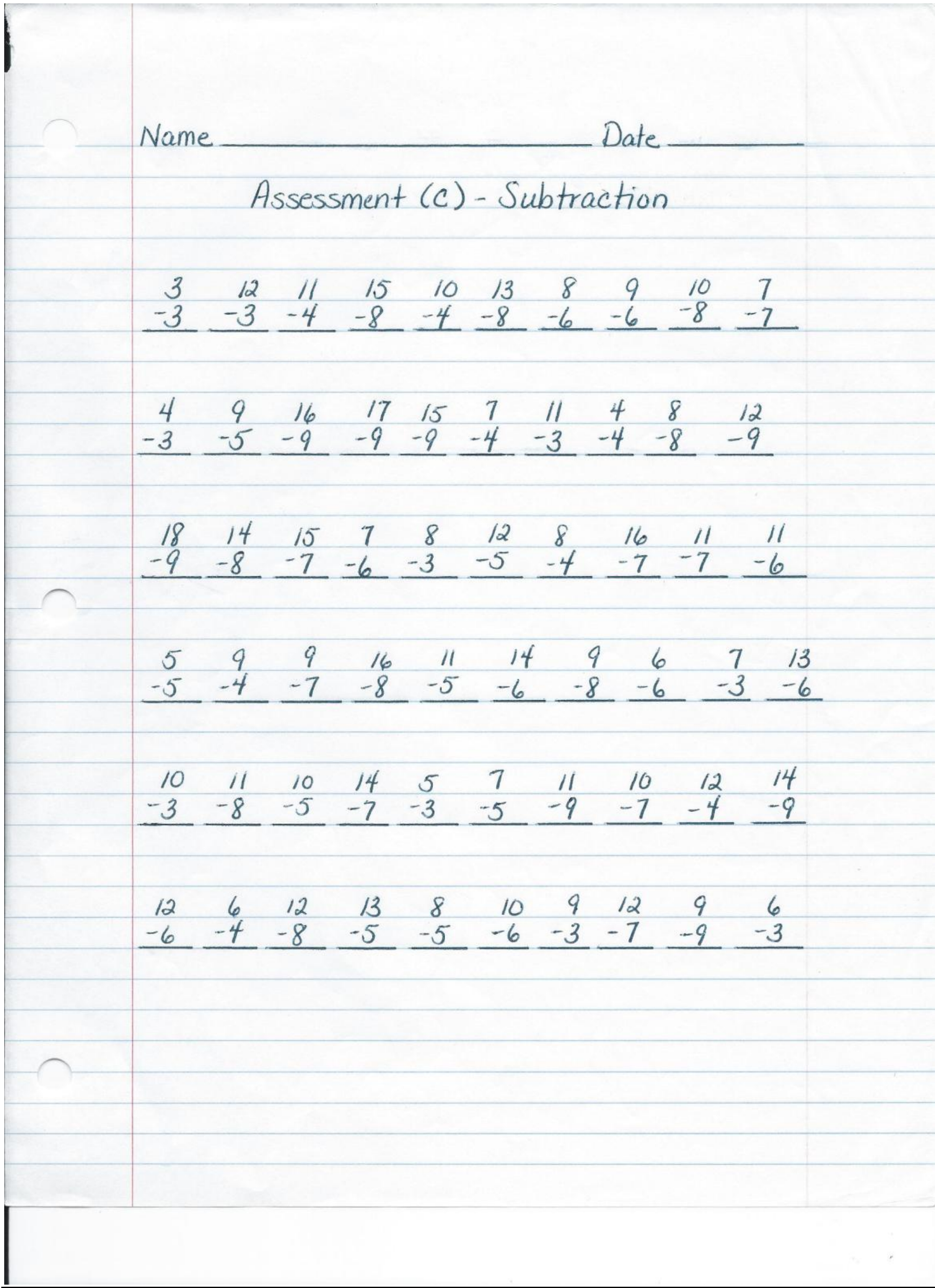
Name ______________________ Date ________

Assessment (B) - Subtraction

9	15	18	8	10	9	12	9	12	5
-9	-7	-9	-6	-5	-7	-8	-4	-9	-5
12	15	8	9	7	17	11	10	11	10
-6	-8	-4	-8	-6	-9	-5	-7	-6	-8
8	16	10	7	11	13	14	11	12	7
-5	-9	-4	-7	-7	-6	-7	-9	-5	-4
14	14	16	4	15	11	8	9	13	9
-8	-6	-7	-4	-9	-4	-8	-6	-8	-5
16	6	7	11	12	12	10	14	13	6
-8	-6	-5	-8	-4	-7	-6	-9	-5	-4
8	13	15	14	13	17	13	5	10	6
-7	-9	-6	-5	-4	-8	-7	-4	-9	-5

Appendix C

Assessment C



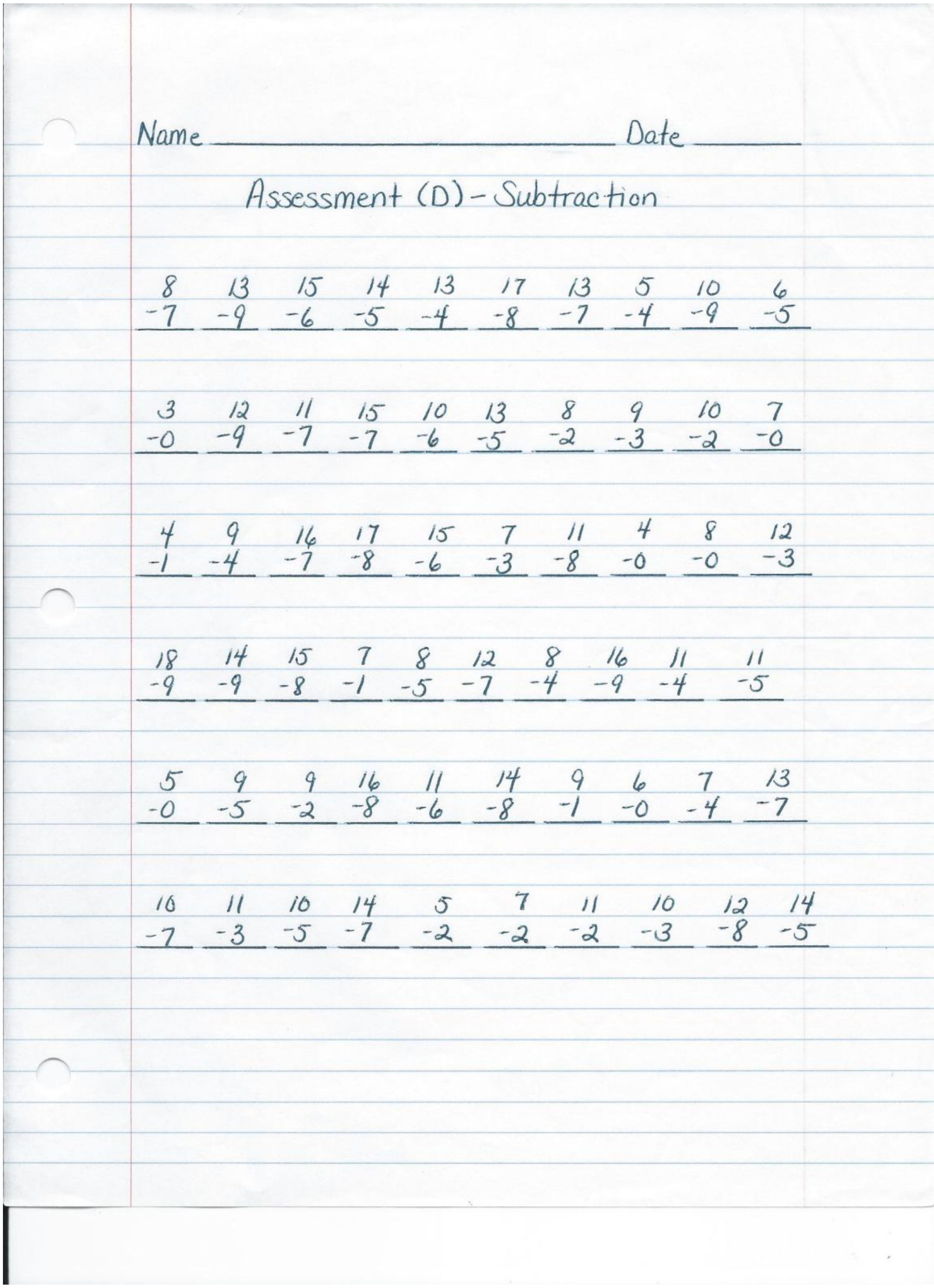
Name ______________________ Date __________

Assessment (c) - Subtraction

3	12	11	15	10	13	8	9	10	7
-3	-3	-4	-8	-4	-8	-6	-6	-8	-7
4	9	16	17	15	7	11	4	8	12
-3	-5	-9	-9	-9	-4	-3	-4	-8	-9
18	14	15	7	8	12	8	16	11	11
-9	-8	-7	-6	-3	-5	-4	-7	-7	-6
5	9	9	16	11	14	9	6	7	13
-5	-4	-7	-8	-5	-6	-8	-6	-3	-6
10	11	10	14	5	7	11	10	12	14
-3	-8	-5	-7	-3	-5	-9	-7	-4	-9
12	6	12	13	8	10	9	12	9	6
-6	-4	-8	-5	-5	-6	-3	-7	-9	-3

Appendix D

Assessment D



Name __________________________ Date ________

Assessment (D) - Subtraction

8	13	15	14	13	17	13	5	10	6
-7	-9	-6	-5	-4	-8	-7	-4	-9	-5
3	12	11	15	10	13	8	9	10	7
-0	-9	-7	-7	-6	-5	-2	-3	-2	-0
4	9	16	17	15	7	11	4	8	12
-1	-4	-7	-8	-6	-3	-8	-0	-0	-3
18	14	15	7	8	12	8	16	11	11
-9	-9	-8	-1	-5	-7	-4	-9	-4	-5
5	9	9	16	11	14	9	6	7	13
-0	-5	-2	-8	-6	-8	-1	-0	-4	-7
10	11	10	14	5	7	11	10	12	14
-7	-3	-5	-7	-2	-2	-2	-3	-8	-5

Appendix E

Assessment E

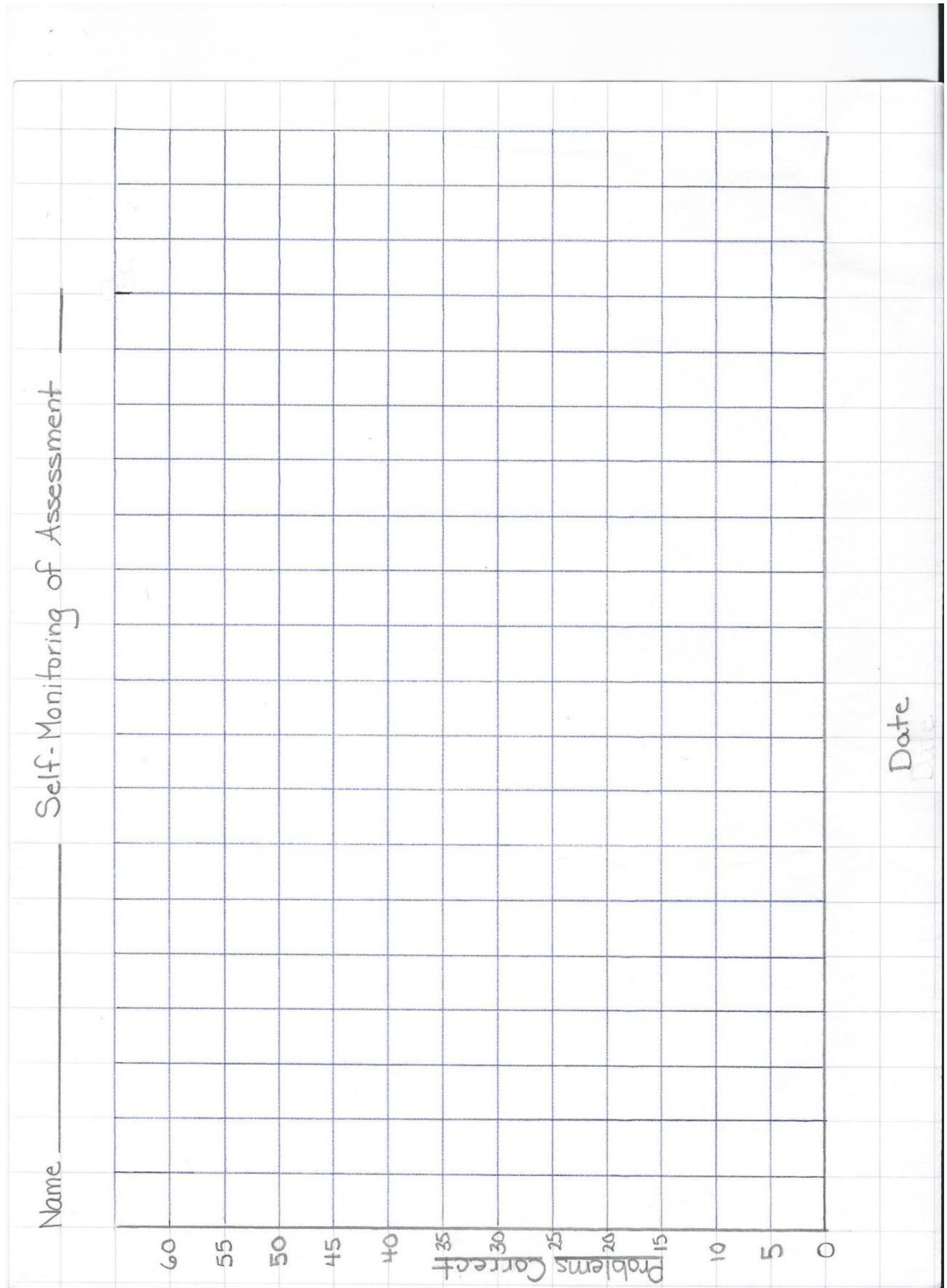
Name ______________________ Date ________

Assessment (E) - Subtraction

12	6	12	13	8	10	9	12	9	6
-6	-4	-8	-5	-5	-6	-3	-7	-9	-3
4	3	6	11	5	7	18	8	15	9
-1	-2	-0	-9	-5	-2	-9	-7	-8	-4
16	13	14	10	3	8	14	16	10	4
-9	-6	-9	-9	-3	-6	-8	-8	-3	-3
5	9	7	13	17	7	15	8	11	1
-3	-8	-6	-9	-8	-0	-6	-4	-3	-0
2	10	14	16	8	15	17	12	10	11
-2	-8	-7	-9	-8	-7	-9	-8	-5	-7
4	6	9	7	14	13	14	9	3	0
-2	-5	-3	-1	-6	-7	-9	-5	-0	-0

Appendix F

Self-monitoring graph



Appendix G

Instructional Procedures (Phase B)

Weeks 2 - 6

Technology

- Students access the Facts Workshop Game at www.everdaymathonline.com by entering their login information and password. (This information can be obtained from the teacher after the teacher enters a class list in the online teacher management system.)

- The students select the operations they will work on (add and subtract).

- Then, they select the difficulty level (bronze).

- Finally, they select the mode. The modes are Rookie Zone, Advanced Zone, Expert Zone, and Beat Your Time. Once the children have worked in each mode for at least three consecutive days, they are free to choose which mode they would like to work on on subsequent days.

- Each level contains ten questions. The children advance through as many levels as they can in five minutes.

Appendix H

Instructional Procedures (Phase C)

Weeks 7 - 11

Technology

- Students access the Facts Workshop Game at www.everdaymathonline.com by entering their login information and password.
- The students select the operations they will work on (add and subtract).
- Then, they select the difficulty level (bronze).
- Finally, they select the mode (Rookie Zone, Advanced Zone, Expert Zone, or Beat Your Time).
- The children advance through as many levels as they can in five minutes.

Self- Monitoring

- The students are required to graph the number of correct responses on a bar graph. The graph used corresponds to the letter of the assessment (A-E).
- The students compare their score and height of the bar to the bar from the previous week.